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(54) Abstract Title: **High-frequency socket connector**

(57) A high frequency electrical connector comprising a socket (500) and a plug (560), the plug insertable into the socket in a first direction (5I), the socket and plug each having multiple electrical contacts (503, 504, 505) which are arranged to electrically interconnect the plug and socket (at 564). The contacts have contact areas aligned so as to be parallel in a first dimension with the first direction, wherein the socket contacts are formed respectively in a first shape, a second shape and a third shape, each shape being different to the other.

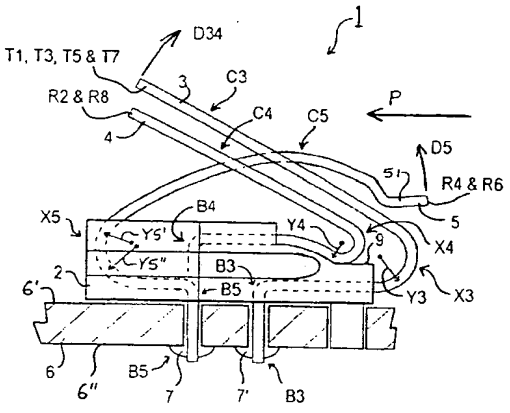


Figure 1

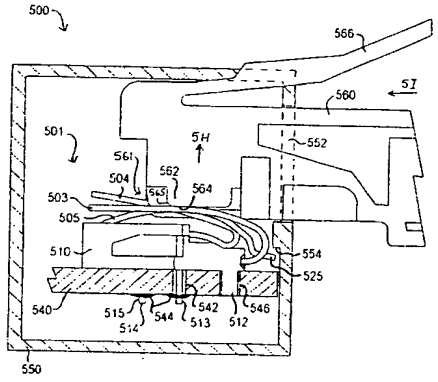


Figure 5

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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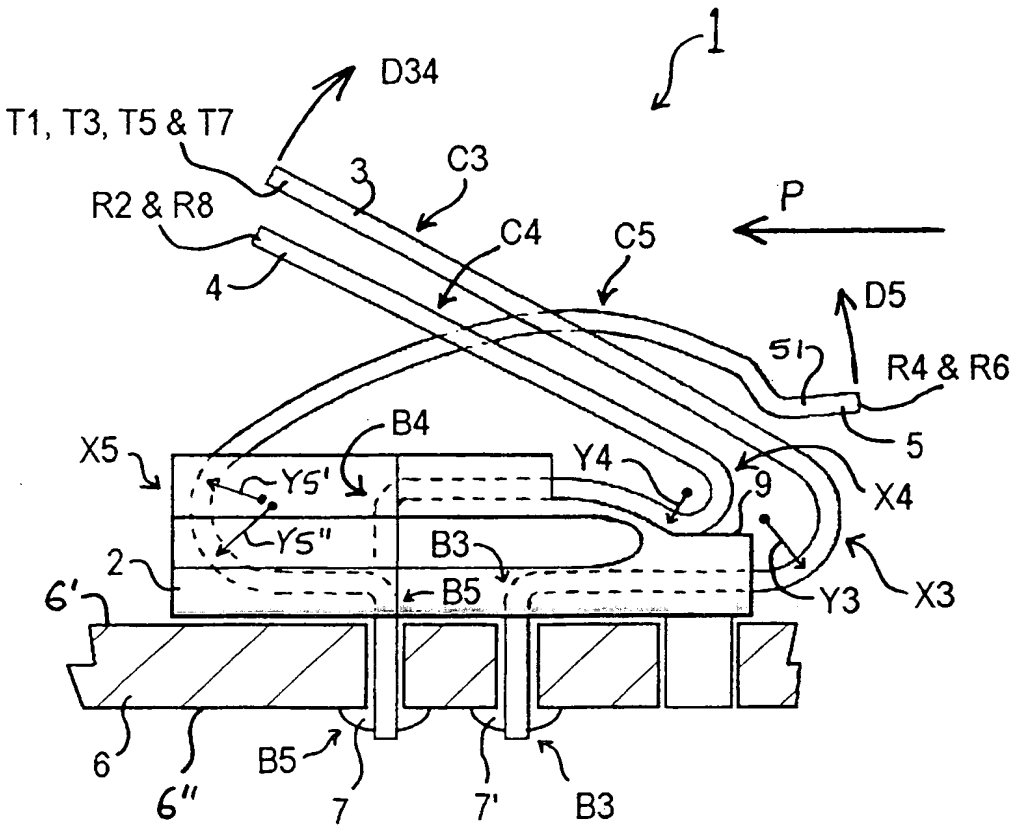



FIGURE 1

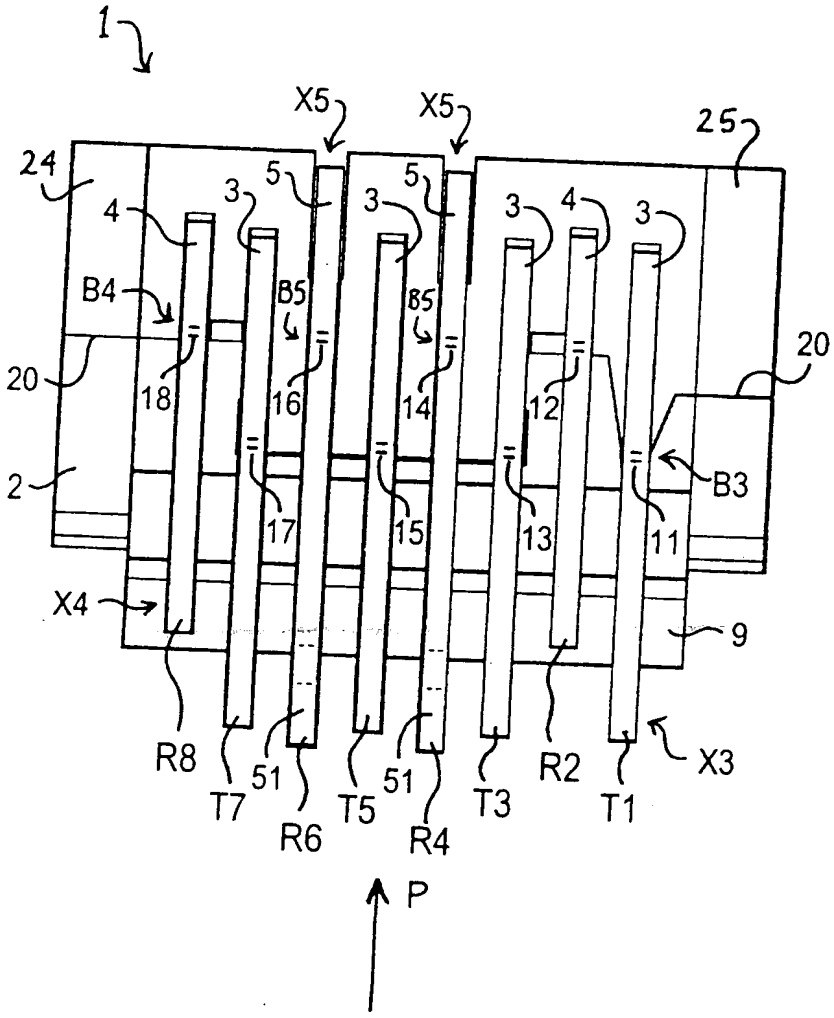



**Figure 2**

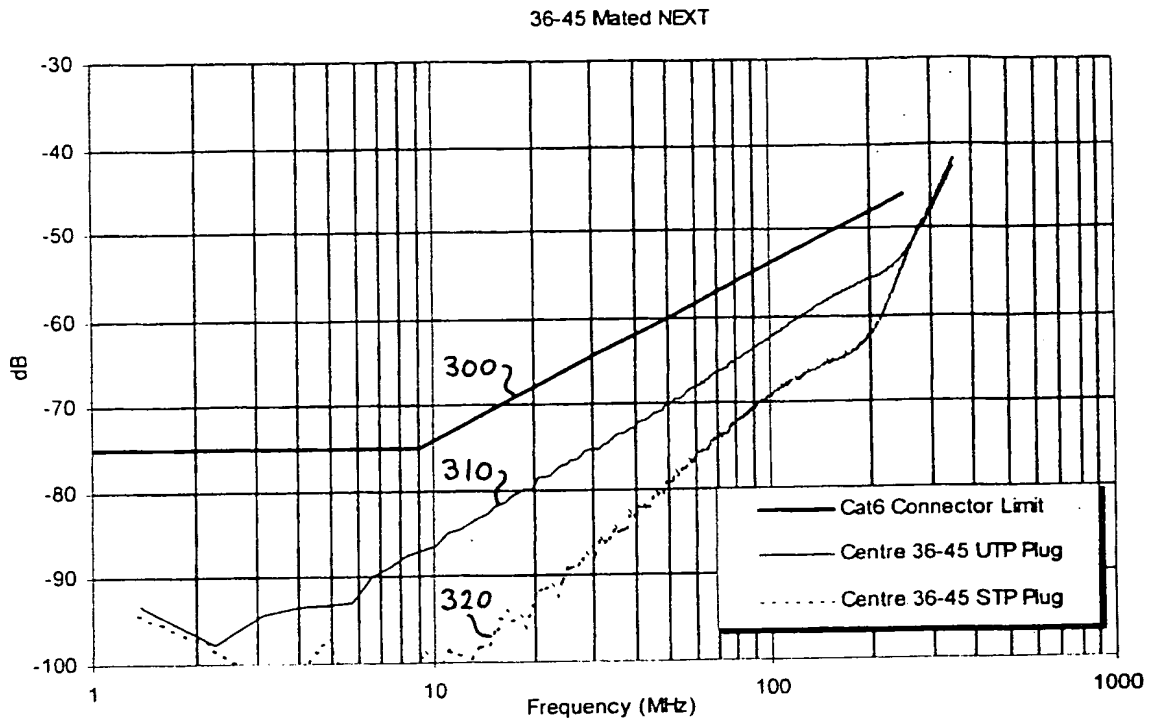



**Figure 3**

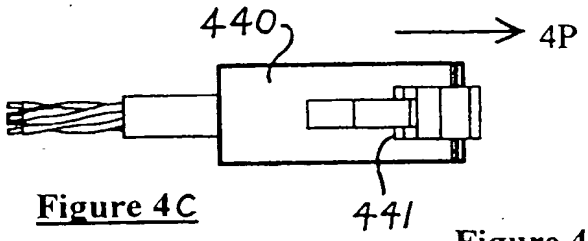



**Figure 4C**

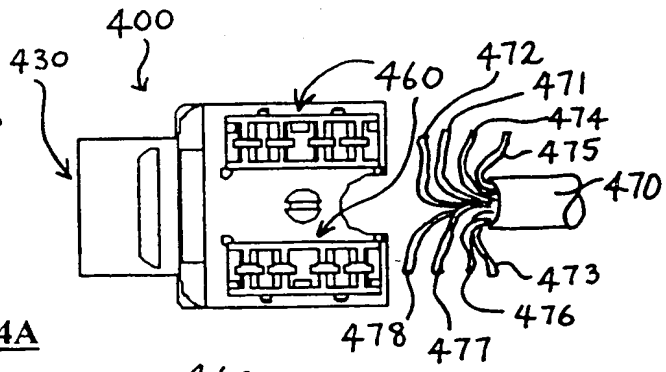
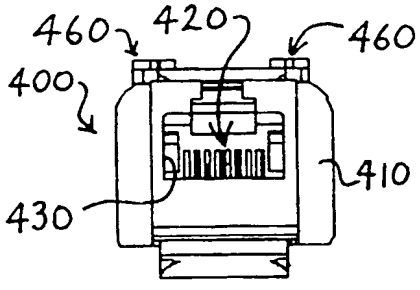



**Figure 4A**



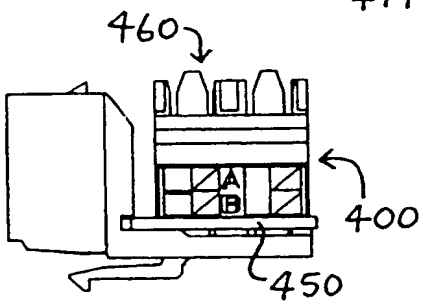




**Figure 4B**

**Figure 4**

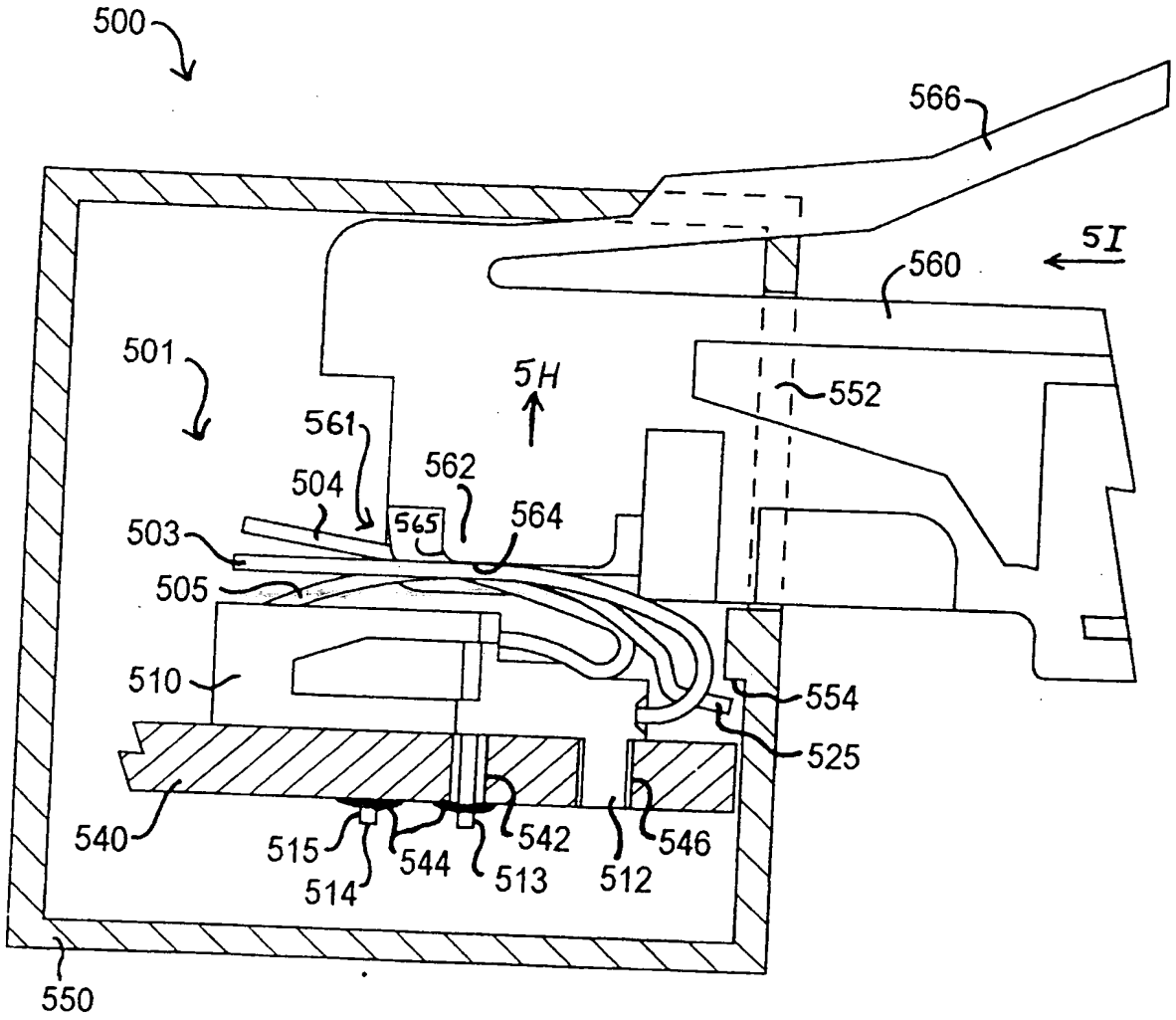



**Figure 5**

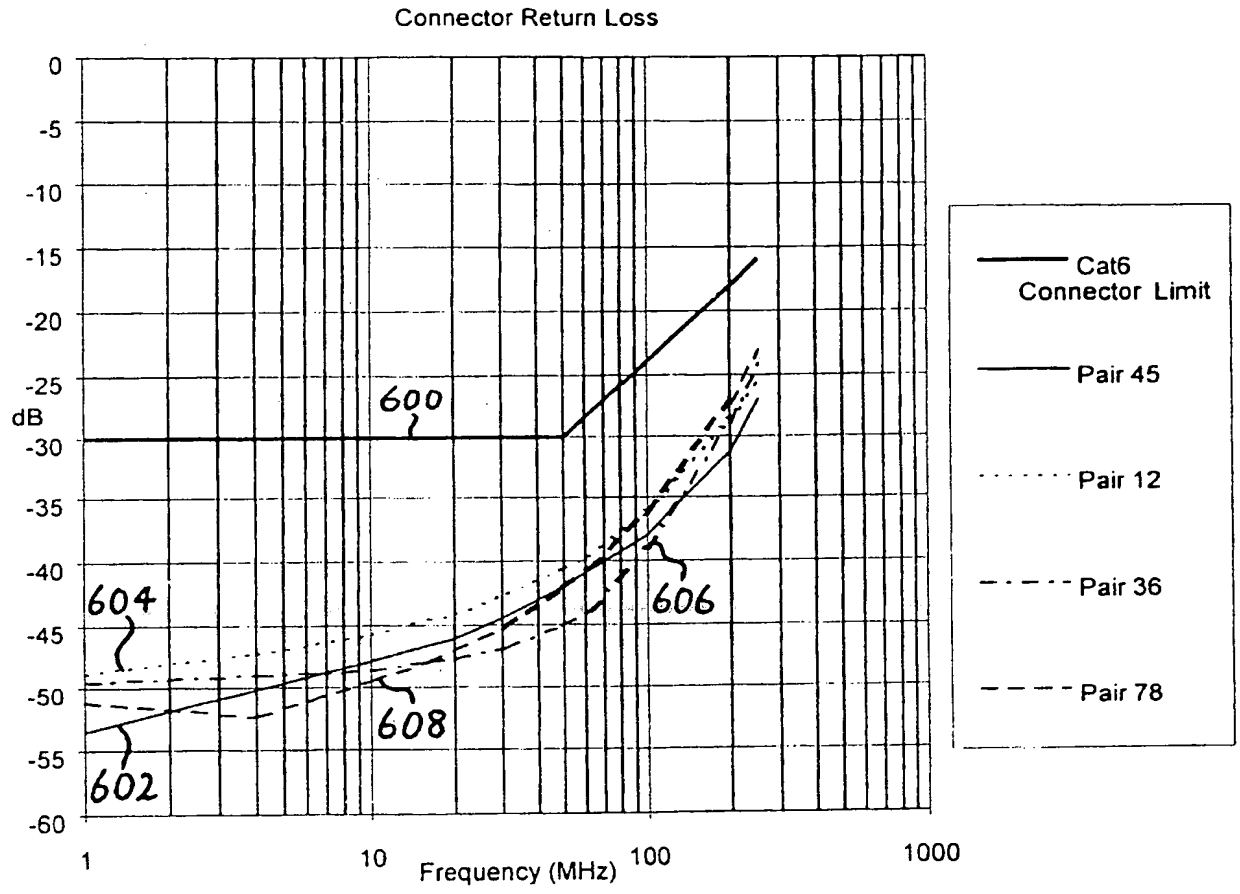



**Figure 6**

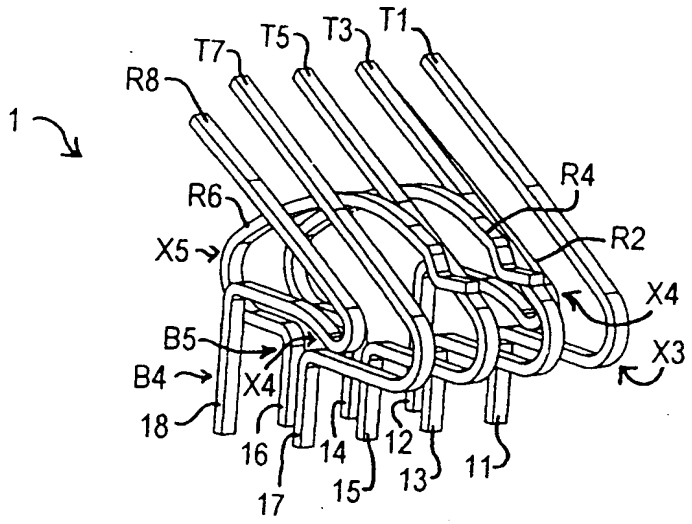



Figure 7A

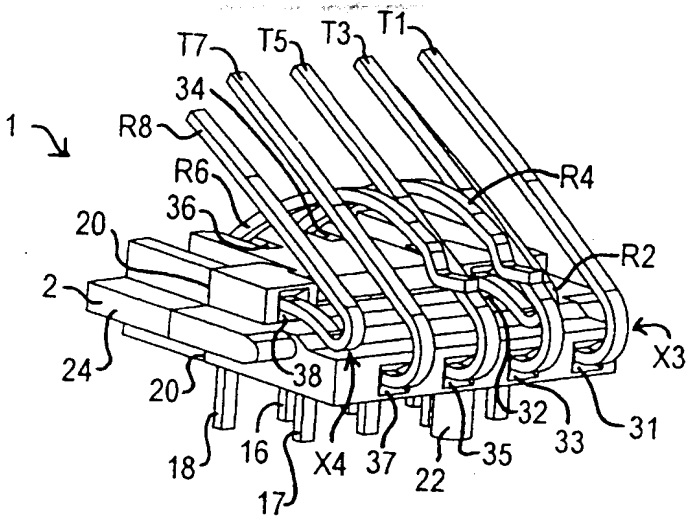



Figure 7

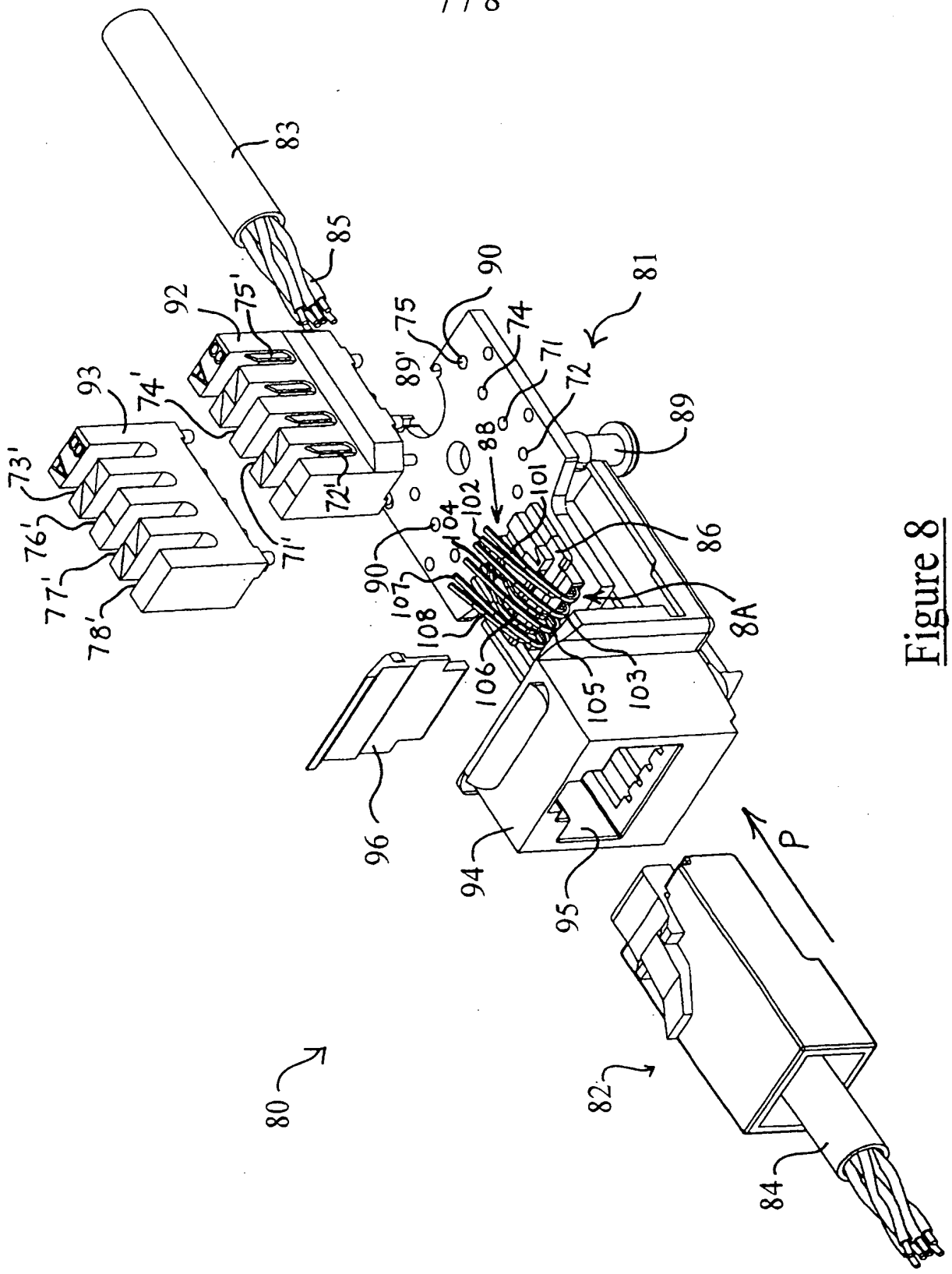



Figure 8

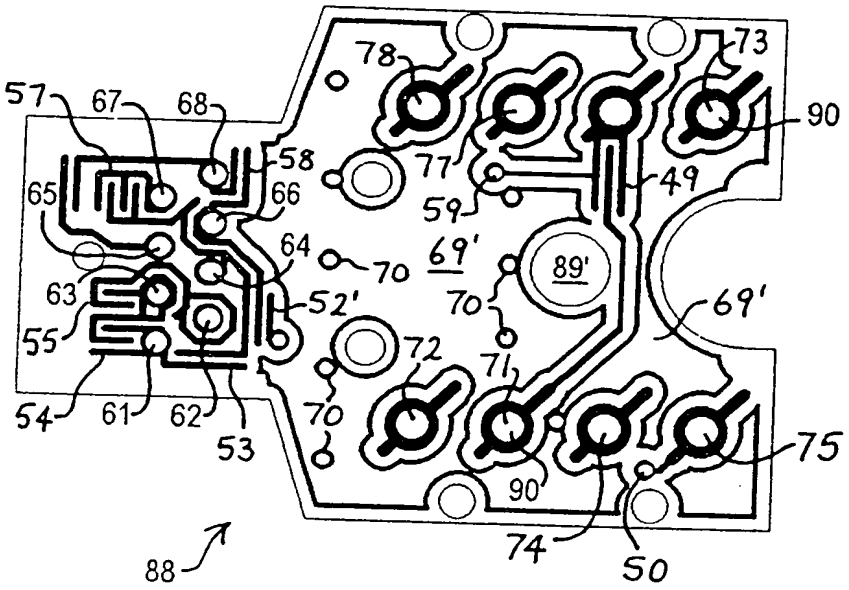



Figure 9

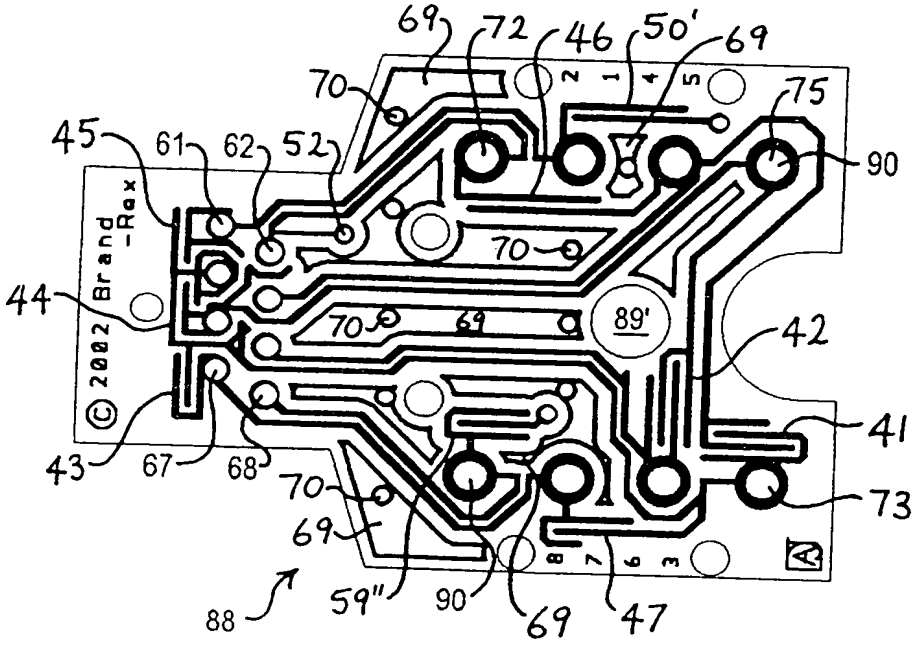



Figure 9A

# Improvements in and relating to electrical connectors

The present invention relates to high frequency electrical connectors, and particularly to electrical contacts provided in electrical sockets for such connectors.

Multiple pole connectors are used in applications such as data communications networks and telecommunications networks. To enable such networks to transmit increased volume of data, it is necessary to increase the operating frequency, and hence the data transfer rate. To ensure compatibility with existing lower operating frequency networks, it is desirable to provide data communications connectors that can operate at high data rates while still remaining backward compatible with older, lower data rate systems.

Data transfer rates are limited by a degradation of the signal and / or signal to noise ratio that occurs during transmission. A factor that may cause such degradation is crosstalk between adjacent pairs of conductors, where a data signal on one pair of conductors induces an electrical signal noise on an adjacent conductor.

By way of example, such a known data communications connector is the RJ45 connector which is provided with eight spring contacts, arranged so that all of the spring contacts run parallel and in line for a substantial proportion of their lengths. This configuration has been sufficient for systems characterised up to 100MHz (Cat 5/5e), provided contact lengths are minimised. However it becomes more difficult, as data rates increase beyond 100MHz systems (i.e. Cat 6 / 250MHz), to deal with crosstalk using the traditional style contact arrangement. This is because crosstalk compensation circuitry is applied relatively late and becomes ineffective at high frequencies.

European patent application no. EP 0,688,473 (Stewart Connector Systems Inc.) describes a known electrical connector for use at a data rate of up to 100MHz. Stewart describes a method of reversing the direction of two contact wires, one from each of two pairs. The intention is to reduce the cross talk arising from the relatively small region where the wires make contact with the plug pins. Stewart does not address a problem arising at higher data rates from crosstalk arising from electro-magnetic coupling of other regions of adjacent contact wires. Hence, such an arrangement is not satisfactory for operation at Category 6 data transfer rates of 250MHz.

According to the present invention, there is provided a high frequency electrical connector comprising a socket and a plug, the plug insertable into the socket in a first direction, the socket and plug each having multiple electrical contacts which are arranged to electrically interconnect the plug and socket, the contacts having contact areas aligned so as to be parallel in a first dimension with the first direction, wherein the socket contacts are formed respectively in a first shape, a second shape and a third shape, each shape being different to the other.

A benefit of the invention is that a high frequency data communications connector for standard RJ45 plugs may be provided with socket contacts formed so as to reduce a contribution of the contacts to crosstalk.

Preferably the socket further comprises a contact array fixedly retained to the socket, the contact array comprising the said multiple socket contacts each having a contact region, a resiling region and a base region, the base region being fixedly retained to the contact array, the contact region arranged for electrical contact with the plug, and the resiling region arranged to resiliently urge the contact region in a direction so that electrical contact is made when the plug is inserted.

A benefit of the contact array is that the multiple contacts may be firmly supported at the base region.

A benefit of the contacts having a resiling region is that satisfactory electrical contact may be reliably made when the plug is inserted into the socket.

Preferably the resiling region of at least a first and a second socket contacts each further comprises a radiused bend region, the bend region of the first socket contact having a smaller bend radius than that of the second socket contact.

A benefit of the different bend radii is that the resiling regions may be spaced further apart than would be possible with contacts having the same bend radii, and hence crosstalk may be reduced.

Preferably the bend regions of at least two adjacent contacts are arranged to be at different heights with reference to a plane coincident with that of contact faces of the plug when the plug is inserted into the socket.

A benefit of the different bend heights is that the base and resiling regions may be spaced further apart than would be possible with contacts having the same bend heights, and hence crosstalk may be reduced.

A further benefit of having different heights is that the shapes of each of the first and second socket contacts, when the plug is inserted, are such that electromagnetic coupling between the two contacts is minimised.

Preferably the base region is further arranged so that an end of the contact is arranged for electrical connection to a circuit board, the circuit board arranged to provide electrical interconnections between the contacts and terminals for connecting to electrical wires, the electrical interconnections being arranged so as to provide inductive coupling or capacitive coupling between particular interconnections. More preferably the coupling being arranged to compensate for an undesired coupling between corresponding interconnections in the plug.

A benefit of the electrical interconnections being arranged so as to provide inductive coupling or capacitive coupling between particular interconnections is that the electrical interconnections may be arranged to compensate for crosstalk generated in the plug. A yet further benefit is that a low cost, durable, high performance component for integration into custom RJ45 connector configurations which can meet Category 6 (i.e. 250MHz specified limits) near end crosstalk (NEXT) requirements with minimum degradation on other parameters, such as "Return Loss", where the amount of energy reflected back to the signal source may be minimised as a connector according to the present invention requires less additional compensation for crosstalk in other components, such as the circuit board, of the electrical socket.

Preferably the base regions of adjacent contacts are displaced from each other in at least two perpendicular directions, in a plane substantially parallel to the said plane coincident with the plane of the contact faces of the plug.

A benefit of the displaced contact base regions is that greater spacing of the circuit board connections may be obtained.

Preferably the said first and second contacts have bend regions at a first end of the array, and at least a third contact is arranged so that it has a bend region at a second end of the array, the first end being opposed to the second end along an axis of insertion of a plug into the socket.

A benefit of the third contact having its bend region at the second end of the array is that a coupling giving rise to near end crosstalk between the third contact and the first and / or second contacts in the bend region is minimised. A further benefit is that coupling arising from proximity of the base regions is also minimised.

Preferably the said first and second contacts are arranged so that when a plug is fully inserted into the socket a free end of each of the contacts extends beyond a contact face of the plug along the said axis of insertion.

A benefit of the free ends of the contacts extending beyond the contact face of the plug is that a risk of damage to the contact on removal of the plug from the socket due to the end of the contacts catching on the plug is avoided.

Preferably the free ends of the first and second contacts are at different heights with reference to the said co-incident plane to each other when a plug is fully inserted into the socket.

A benefit of the free ends being at different heights is that a coupling giving rise to near end crosstalk between the ends of the contacts is reduced.

Preferably a free end of the third contact is arranged so that it is restrained in a direction perpendicular to the said axis of insertion of a plug, and the contact is further arranged to abut a stop when the plug is absent from the socket.

A benefit of the free end of the third contact being restrained is that the free end may not relax to an unstressed condition where it would prevent the insertion of a plug into the socket, while allowing the third contact to provide a sufficiently high contact force

Preferably the bend regions of each contact are each in a plane parallel to and spaced from the plane of each other contact, the plane being parallel to the said axis of insertion.

A benefit of the bend regions being each in a plane parallel to and spaced from each other contact is that the contact regions may be arranged to reliably make contact with the plug contacts.

Specific embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a side view of a contact array support block with resilient contacts mounted to it according to the invention;

Figure 2 is a plan view of the support block and contacts shown in Figure 1;

Figure 3 is a graph showing near end crosstalk (NEXT) measured on a socket incorporating the support block of Figure 1;

Figure 4 is an end view of a first embodiment of an electrical socket according to the invention;

Figure 4A is a plan view of the electrical socket shown in Figure 4;

Figure 4B is a side view of the electrical socket shown in Figure 4;

Figure 5 is a side view of a second electrical socket having the contact array shown in Figure 1, also showing the outline of a plug inserted into the socket;

Figure 6 is a graph showing return loss measured on a socket incorporating the support block of Figure 1;

Figure 7 is a perspective view of the support block and contacts shown in Figure 1;

Figure 7A is the same perspective view as shown in Figure 7, but with the support block omitted to show detail that would otherwise be hidden;

Figure 8 is an exploded perspective view of a third embodiment of an electrical connector according to the invention;

Figure 9 is a view of a component side of a circuit board forming part of the third embodiment; and

Figure 9A is a view of the circuit board shown in Figure 9 from the solder side of the board.

From Figure 1, a side view of a contact array 1 according to the present invention for an electrical socket comprising a support block 2 with a plurality of resilient contacts 3, 4 and 5 mounted to the support block. Each of the resilient contacts has a contact region C3, C4 and C5, a resilient bend region X3, X4 and X5 and a base region B3, B4 and B5. The base region of each contact is arranged for solder connection to a printed circuit board 6 with solder 7, 7', the contact region arranged so that electrical contact may be made with a plug (shown in Figure 4) inserted into the socket, and the bend region arranged to resiliently urge the contact region in a direction D34 and D5 for contacts 3 and 4, and contacts 5 respectively, so as to ensure satisfactory electrical contact is made when a plug is inserted by inserting into the socket (shown in Figures 4 and 8) in the direction of arrow P. Contacts 4 are formed with the resilient bend regions X4 having a smaller bend radius Y4 than that of an adjacent said contact 3 which has a larger bend radius Y3. Contacts 5 are formed with the resilient bend region having a bend radius Y5 having a maximum value Y5" and a minimum value

Y5'. The minimum value Y5' being greater than the value of Y3 and the maximum value Y5" being greater than the value of Y4.

The printed circuit board 6, may be arranged so that conductive tracks are provided on each side 6' and 6", so that the tracks may be arranged to obtain a desired electromagnetic coupling to compensate for undesirable electromagnetic coupling remaining in the plug and socket connection.

In Figure 2 contacts 3 of Figure 1 correspond to contacts T1, T3, T5 and T7, and contacts 4 correspond to R2 and R4, and contacts 5 correspond to contacts R4 and R6. It may be seen that the contacts are arranged to be parallel to each other, along the direction of arrow P. Base 2 is provided with side protrusion 24 and 25 and surface 9 which is arranged to provide support to the contacts 4, that is R2 and R8. Likewise the base is arranged to provide support to the other contacts, ensuring that they are able to resile at the resilient bend region X3, X4 and X5, and also to constrain them to the said parallel arrangement, and to provide support to the base region B3, B4 and B5 so that undue stress is not applied to the solder joints at the circuit board. From Figure 2, it may be seen that the base regions 11 to 18 inclusive of the contacts T1, R2, T3, R4, T5, R6, T7, R8 respectively, are arranged so as form a two dimensional array so that the tracks on the circuit board may be spaced widely apart. Base 2 is constructed as two interlocking components joining along line 20 to facilitate the secure mounting of the contacts to the base. Contacts 5 are provided with a bent end 51 which is used to provide a location for the contact (this may be seen from Figure 5). The two dimensional array is in a plane substantially parallel to a plane of contact faces of a plug when inserted into the socket as described with reference to Figure 5. The said plane is also parallel to the plane of the plan view of Figure 2.

From Figure 5 a side view of a high frequency electrical socket 500 having a contact array 501 corresponding to that shown in Figure 1 at array 1. The electrical socket has a housing 550, with an aperture 552, through which plug 560 (shown in outline, and partially inserted into the socket) may be inserted into the socket. Plug 560 is provided with an array of plug contacts 561 which are arranged to make electrical contact with all or some of the socket contacts 503, 504, and 505 of the socket array 501. The plug 560 is arranged so that the contacts 503, 504, and 505 (other contacts correspond to these) are resiliently deflected such that a suitable contact force is obtained where the socket contacts make physical contact with the plug contacts so that a low electrical resistance path is established between the corresponding plug and socket contacts.

The plug 560 is arranged so that each plug contact 562 (only one visible) has a flat contact face 564. Each of the plug contact faces is arranged to be substantially on a plane with each of the other plug contact faces. The plane being perpendicular to direction of arrow 5H.

From Figure 5, it can be seen that when deflected by the insertion of a plug, the contacts 503, 504, 505 are preferably arranged to make contact with the plug contacts along the contact faces 564, rather at a leading edge 565 of the respective contacts 562. This ensures reliable operation even after a large number of repetitive insertion of a plug into the socket.

To ensure a satisfactory low resistance contact is achieved when a plug is inserted into the socket, each of the socket contacts 503, 504, and 505 is arranged so that each respective plug contacts 562 (others correspond) has a rubbing motion in the direction of arrow 5I as the plug is inserted by moving it in the direction of arrow 5I relative to the socket. To facilitate the insertion of the plug, contacts 505 are provided with a bent end 525 which is arranged to locate under protrusion 554 of the body 550. Hence a height in the direction of arrow 5H of the contacts 505 when a plug is not inserted into the socket is restrained so that the contact does not inhibit the insertion of a plug, while the contact may be arranged to provide a suitably high contact force when deflected by the insertion of a plug.

The socket array 501 also comprises a support block 510, having a location pin 512 which is arranged to locate in a hole 546 of a circuit board 540. Circuit board 540 is also provided with holes (only one shown 542) through which the base regions 513, 514, 515 of each of the contacts 503, 504, 505 respectively, may protrude. Solder 544 is used to make electrical contact between each of the contacts and a corresponding solder pad (not shown) on the circuit board.

From Figure 5, it may be seen that the contacts 503, 504 and 505 are different shapes so that when deflected they do not lie in a plane with each other, but cross over each other so that a length of each contact that may be substantially in the same plane as another adjacent contact is minimised.

Hence, the invention is arranged to reduce parallel and in line running of adjacent (Ring-to-Tip) contacts.

Further the contacts of the invention is arranged to obtain a distance between spring bend regions of the adjacent Ring and Tip wires.

Further, the contacts of the invention are arranged to reinforce Ring-to-Ring coupling and Tip-to-Tip coupling, particularly between pairs 3 & 6 and 4 & 5.

Hence, electro-magnetic coupling between adjacent plug and socket contacts may be minimised. Hence, crosstalk induced in a contact by the signal flowing though an adjacent contact is minimised.

Fig. 3 shows the near end crosstalk (NEXT) measured between pairs 3 & 6 and 4 & 5 on an electrical socket outlet utilising the invention and using TIA/EIA 568B Category 6 Centre Test Plugs (Unshielded and Shielded plugs). The 'Table 1' below shows corresponding NEXT results values at test frequencies of 100MHz and 250MHz.

| Frequency (MHz) | NEXT Using UTP Test Plug (dB) | NEXT Using STP Test Plug (dB) | TIA/EIA 568B NEXT Limit (dB) |
|---|---|---|---|
| 100 | 62.5 | 69.3 | 54.0 |
| 250 | 53.1 | 53.9 | 46.1 |

**Table 1**

The Category 6 standard accepted in the industry, such as "ANSI/TIA/EIA-568-B.2-1 - Commercial Building Telecommunications Cabling Standard Performance Specifications for 4-Pair 100 Ohm Category 6 Cabling" published in June 2002 by the 'Telecommunication Industry Association', specifies requirements for insertion loss, near-end crosstalk (NEXT) loss, equal level far-end crosstalk (ELFEXT), return loss, propagation delay, and delay skew requirements for 100 Ohm 4-pair category 6 cabling, cables, and connecting hardware. From Figure 3, a graph showing near end crosstalk (NEXT) measured on a socket incorporating the support block of Figure 1, such as the socket shown in Figure 5, the Category 6 connector limit for near end crosstalk between the cable pairs 3 & 6 and 4 & 5 is shown by line 300. Figure 3 also shows the corresponding near end crosstalk measured for an unshielded twisted pair plug used with a socket according to this invention at line 310, and at line 320 shows the corresponding near end crosstalk measured for a shielded twisted pair plug used with a socket according to this invention.

It can be seen from Figure 3, that for an unshielded twisted pair plug when used with a socket according to this invention provides a performance of greater than 9dB better than the standard for most of the frequency range of interest.

Further, a shielded twisted pair plug when used with a socket according to this invention provides a performance of greater than 15dB better than the standard for most of the frequency range of interest.

Furthermore, this invention can provide connector solutions of which will conform to Category 6 specification limits for the full set (twelve) of de-embedded NEXT test plugs i.e. for all pair-to-pair combinations.

Such a performance improvement provides a significant improvement in the performance and the reliability of a network system using sockets according to the present invention.

Figure 4 is an end view of an electrical socket 400 according to the invention is shown having a housing 410 and an array of contacts 420. Figure 4A is a plan view of the electrical socket 400 shown in Figure 4, and Figure 4B is a side view of the same electrical socket 400. The housing 410 is provided with an aperture 430 through which a plug 440 may be inserted in the direction of arrow 4P so as to make electrical contact with each of the contacts of the array of contacts 420. The electrical socket 400 also has a circuit board 450 and an array of terminals 460. Each of the contacts of the array of contacts is electrically connected to one of the terminals through conductive tracks mounted on the circuit board. Each of the terminals is arranged to be connected to a conductor 471 - 478 inclusive of a four pair cable 470. Each of the pairs in the cable is preferably arranged so as to minimise crosstalk between other pairs, by means such as twisting. Plug 440 is provided with a latch 441 to releasably retain the plug in the socket 400.

The conductive tracks (not shown in Figure 4) are arranged so as to balance the impedance of the electrical socket and plug combination so as to reduce the amount of energy reflected to its source by an impedance mismatch between the connector and the cable. Such reflected energy is known as Return Loss.

The conductive tracks of a socket according to the invention may be arranged so as to build in coupling to oppose crosstalk generated in the interconnecting plug 440 where necessary.

Further, the conductive tracks may be arranged to more effectively reduce the Return Loss than known connectors since it is not necessary to arrange the conductive tracks so as to provide as much compensation for near-end crosstalk as in the known connectors.

Figure 6 is a graph showing Return Loss expressed as the ratio of reflected signal to source signal measured in decibels measured for each of the pairs of wires 1 & 2 (at line 604) and 3 & 6 (at line 606) and 4 & 5 (at line 602) and 7 & 8 (at line 608) on a socket incorporating the support block of Figure 1 and using TIA/EIA 568B Category 6 Centre Test Plugs (Unshielded and Shielded plugs). The TIA/EIA 568B Standard specifies a Category 6 Connector Limit which is shown by the solid line (line 600).

The 'Table 2' below shows corresponding Return Loss results values at test frequencies of 100MHz and 250MHz, compared with the TIA/EIA standards limit. It can be seen that at 100MHz, a connector according to the invention achieves a result more than 12dB better than the standards requirement. Further at 250 MHz, the connector according to the invention achieves a result more than 7dB better than the standards requirement.

In each case, the results achieved are 50%better than the standards requirement

| Frequency (MHz) | Return Loss Pair 45 (dB) | Return Loss Pair 12 (dB) | Return Loss Pair 36 (dB) | Return Loss Pair 78 (dB) | TIA/EIA 568B NEXT Limit (dB) |
|---|---|---|---|---|---|
| 100 | 37.9 | 36.2 | 39.1 | 36.1 | 24 |
| 250 | 27.1 | 25.6 | 24.2 | 23.3 | 16 |

**Table 2**

The prior art patent EP 0,688,473 (Stewart Connector Systems Inc.) uses a method of reversing the direction of two contact wires, one from each of two pairs. The arrangement of Stewart only deals with the relatively small region where the wires make contact with the plug pins. The present invention acknowledges that the spring bend region of the contact wires generate relatively high amounts of crosstalk due to

concentration of electromagnetic fields combined with effective additional parallel/in-line proximity of adjacent wires. The invention serves to distance adjacent wires (Rings & Tips) at the spring bend region thus effectively reinforcing coupling between alternate wires (Tip to Tip). Since the 3 & 6 wire pair envelops the 4 & 5 pair, sufficient separation can not easily be achieved, while still maintain mechanical integrity, therefore requiring bending two of the wires (Ring wires 4 & 6) in reverse direction from normal. All other wire pairs have alternate bend regions displaced in both vertical and horizontal planes. Stewart does not teach the means of showing the benefits to be obtained by distancing the contacts at the bend region.

An additional benefit in distancing the wires of the 3 & 6 and 4 & 5 pairs is that they provide additional Ring-to-Ring & Tip-to-Tip coupling which is desirable to counter the opposite coupling effect in the mating plug.

Figure 7 shows a perspective view of the contact array 1 and the support block 2 and contacts T1, R2, T3, R4, T5, R6, T7, R8 shown in Figures 1 and 2. Figure 7A is the same perspective view as shown in Figure 7, but with the support block 2 omitted to show detail of the contacts that would otherwise be hidden. These Figures show contact support surfaces 31 to 38 inclusive for each of the contacts T1, R2, T3, R4, T5, R6, T7, R8 respectively. Support surfaces 31,32, 33, 35, 37, and 38 assist in the support of each of the contacts to ensure that in normal use they are not subject to a deflection that would result in a permanent change in the shape of the contact. Hence a desired contact force ensuring good electrical contact between the socket and the plug may be maintained for a large number of plug insertions.

Figure 8 is an exploded perspective view of a third embodiment of the invention of a two part high frequency electrical connector 80, comprising a socket 81 and a plug 82 to which are connected twisted pair cables 83 and 84 respectively. The plug is an industry standard Category 6 UTP (unshielded twisted pair) plug. The plug is insertable into the socket in a first direction of arrow P. The socket 81 has a contact array 86 comprising multiple electrical contacts 101 to 108, and the array is mounted to a circuit board 88, which is drilled with holes 90 (only two labelled for clarity) to receive insulation displacement connectors 92 and 93, to which conductors 85 of the cable 83 are connected. Socket 81 has a housing 94 with an aperture 95 to receive the plug 82. A closure plate 96 is provided to close the rear of the housing when the circuit board is in position. Fastener 89 is provided to retain the circuit board to the housing 94 by insertion of the fastener 89 through hole 89'.

Electrical contacts 101, 103, 105, and 107 are a first shape with a large bend radius at a leading end 8A of the contacts as the plug is inserted, contacts 102 and 108 are a second shape with a small bend radius at the leading end, and contacts 104 and 106 are a third shape oriented so that they have a bend radius at a trailing end 8B as the plug is inserted.

Figure 9 is a view of a component side of the circuit board 88 shown in Figure 8 and Figure 9A is a view of the solder side of the board. From Figure 9, the holes 61 to 68 inclusive are for receiving the ends of the base regions of the contacts 101 to 108 inclusive respectively. Holes 71 to 78 respectively receive the pins of the insulation displacement connectors 92 and 93. Holes 71 to 78 are the electrical terminations of the circuit board tracks and are connected by soldering to the wire terminations 71' to 78' respectively. A number of through plated holes 70 (only some labelled) are provided to electrically interconnect copper plated areas 69 (only some labelled) of the solder side and copper plated areas 69' component sides of the circuit board. Through plated hole 52 interconnects the solder side pin 62 with the component side track 52', to provide coupling between pins 2 and 6. Coupling is also provided at 53 between pins 1 and 4, at 54 between pins 1 and 3, at 55 between pins 2 and 3, at 56 between pins 5 and 8, at 57 between pins 4 and 7, at 58 between pins 6 and 8, at 49 between pins 1 and 6, at 59" between pins 6 and 8 and by means of through plated hole 59, at 41 between pins 3 and 4, at 42 between pins 5 and 6, at 43 between pins 3 and 7, at 44 between pins 3 and 5, at 45 between pins 1 and 3, at 46 between pins 2 and 4, at 47 between pins 3 and 7, and at 50' between pins 1 and 5 by means of through plated hole 50.

It should also be noted that the parallel tracks on the board interconnecting the socket contact pins and the insulation displacement connectors also provide coupling. The copper plated areas 69 serve to provide separation between different tracks.

Reverse coupling for over-compensation at the front end is provided at 41 and 42 for pairs 3 & 6 and 4 & 5.

The effect of coupling at 59" is to reduce adverse effects arising from the wire terminations of the insulation displacement connectors 92 and 93.

Between alternate pins of the insulation displacement connectors, the coupling is provided between alternate pairs of the pins to reduce the effect of the coupling within the insulation displacement connector.

CLAIMS

1. A high frequency electrical connector comprising a socket and a plug, the plug insertable into the socket in a first direction, the socket and plug each having multiple electrical contacts which are arranged to electrically interconnect the plug and socket, the contacts having contact areas aligned so as to be parallel in a first dimension with the first direction, wherein the socket contacts are formed respectively in a first shape, a second shape and a third shape, each shape being different to the other.

2. A high frequency electrical connector as claimed in claim 1, wherein the socket further comprises a contact array fixedly retained to the socket, the contact array comprising the said multiple socket contacts each having a contact region, a resiling region and a base region, the base region being fixedly retained to the contact array, the contact region arranged for electrical contact with the plug, and the resiling region arranged to resiliently urge the contact region in a direction so that electrical contact is made when the plug is inserted.

3. A high frequency electrical connector as claimed in claim 2, wherein at the resiling region of at least a first and a second socket contacts each further comprises a radiused bend region, the bend region of the first socket contact having a smaller bend radius than that of the second socket contact.

4. A high frequency electrical connector as claimed in claim 3, wherein the bend regions of at least two adjacent contacts are arranged to be at different heights with reference to a plane coincident with that of contact faces of the plug when the plug is inserted into the socket.

5. A high frequency electrical connector as claimed in any one of claims 2 to 4, wherein the base region is further arranged so that an end of the contact is arranged for electrical connection to a circuit board, the circuit board arranged to provide electrical interconnections between the contacts and terminals for connecting to electrical wires, the electrical interconnections being arranged so as to provide inductive coupling or capacitive coupling between particular interconnections, the said coupling being arranged to compensate for an undesired coupling between corresponding interconnections in the plug.

6. A high frequency electrical connector as claimed claim 5, wherein the base regions of adjacent contacts are displaced from each other in at least two perpendicular directions, in a plane substantially parallel to the said plane coincident with the plane of the contact faces of the plug.

7. A high frequency electrical connector as claimed in any of the preceding claims, wherein the said first and second contacts have bend regions at a first end of the array, and at least a third contact is arranged so that it has a bend region at a second end of the array, the first end being opposed to the second end along an axis of insertion of a plug into the socket.

8. A high frequency electrical connector as claimed in any of the preceding claims, wherein the said first and second contacts are arranged so that when a plug is fully inserted into the socket a free end of each of the contacts extends beyond a contact face of the plug along the said axis of insertion.

9. A high frequency electrical connector as claimed in claim 6, wherein the free ends of the first and second contacts are at different heights with reference to the said co-incident plane to each other when a plug is fully inserted into the socket.

10. A high frequency electrical connector as claimed in claim 6, wherein a free end of the third contact is arranged so that it is restrained in a direction perpendicular to the said axis of insertion of a plug, so that the free end does not prevent the insertion of a plug into the socket.

11. A high frequency electrical connector as claimed in any of the preceding claims, wherein the bend regions of each contact are each in a plane parallel to and spaced from the plane of each other contact, the plane being parallel to the said axis of insertion.

12. A high frequency electrical connector, substantially as hereinbefore described and with reference to the accompanying drawings.

13. A socket for the high frequency electrical connector of any one of claims 1 to 12.

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|---|---|---|---|
| **Application No:** | GB 0222891.4 | **Examiner:** | Frederick Fee |
| **Claims searched:** | 1 to 13 | **Date of search:** | 15 January 2003 |

# Patents Act 1977 : Search Report under Section 17

## Documents considered to be relevant:

| Category | Relevant to claims | Identity of document and passage or figure of particular relevance | |
|---|---|---|---|
| X | 1 to 11, 13 | US 2002/0052145 A1 | [PHOMMACHANH] |
| X | 1 to 11, 13 | US 6428362 B1 | [PHOMMACHANH] contacts 34, figures 1, 3, 4 |
| X | 1 to 11, 13 | US 6089923 | [PHOMMACHANH] contacts 34, figures 1, 3, 4 |
| X | 1, 2, 8, 13 | US 2001/0001752 A1 | [VIKLUND] figures 37 to 41 show at least three different contacts |
| X | 1, 2, 8, 13 | US 6139371 | [TROUTMAN] figures 4 to 6 |
| X | 1, 2, 8, 13 | WO 02/15345 A1 | [WIREMOLD] figures 7A, 9, e.g. contacts in cavities 204D, 204E and 204H differ |
| X | 1, 2, 8, 13 | WO 01/57968 A2 | [SIEMON] figures 44 to 47 show different contact |

Categories:

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|---|---|---|---|
| X | Document indicating lack of novelty or inventive step | A | Document indicating technological background and/or state of the art. |
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## Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]:

H2E

Worldwide search of patent documents classified in the following areas of the IPC[7] :

H01R

The following online and other databases have been used in the preparation of this search report :

WPI, JAPIO, EPODOC